Attorney Docket No. 244413US-237729-237729-23

TITLE OF THE INVENTION

COMPOSITE YARN AND PRODUCTS MADE THEREFROM

BACKGROUND OF THE INVENTION

Field of Invention

The present invention relates generally to yarns, fabrics and protective garments knitted of such yarns. More particularly, the present invention relates to a cut-resistant composite yarn construction which provides effective cut resistance for a protective garment without the use of expensive high performance fibers.

Discussion of the Background

In many industries, it is desirable to provide protective garments, particularly gloves, to protect employees from being cut. Ideally, such garments should provide an acceptable amount of cut resistance while possessing suitable flexibility and durability. To this point knit garments having these qualities have been constructed from yarns that include "high performance" fibers to achieve enhanced cut resistant performance. These yarns are constructed using wrapping technique wherein in a core comprising of a single or multiple strands is wrapped with one or more additional strands. Either the core or the wrap strands may include strands comprised of a high performance fiber. Typical of these include the cut resistant yarn disclosed in U.S. Pat. Nos. 4,777,789; 4,838,017 and 5,119,512. These patents disclose the use of well-known "high performance" fibers which, as used herein, means fibers such as extended chain polyethylene (Spectra®. brand fiber by Allied) or aramid (Kevlar® brand fiber by DuPont).

The use of these high performance fibers to make cut-resistant composite yarns and garments has not come without certain disadvantages. First, articles made from these high performance fibers may be stiff and, particularly in the case of protective gloves, may cause the wearer to lose a certain amount of tactile sense and feedback. This loss of sensitivity can be important for workers in the meat processing industry.

Another potential drawback to the use of high performance fibers is their cost. For example, the unit length cost for high performance fiber easily may be several times that of the next most expensive component of a composite, cut-resistant yarn. It would be very desirable to substantially reduce or eliminate the high performance fiber content of a cut-resistant composite yarn.

One solution to these issues has been proposed in U.S. Patent 6,363,703 to Kolmes. In that patent, the composite yarn has a core of at least one fiberglass strand, and requires at least one wire strand wrapped around the fiberglass core strand, followed by one or more cover strands wrapped around the wire and fiberglass, with the cover strands being made from non-metallic non-high performance materials.

There remains a need for a cut-resistant yarn construction offering an effective level of cut resistance performance at a cost savings compared to composite yarns that include high performance fibers, without the need for wrapped wire constructions.

SUMMARY OF THE INVENTION

Accordingly, one object of the present invention is to provide a composite yarn containing no high performance fibers that has the cut-resistance of composites containing high-performance fibers, while maintaining good feel and flexibility, without a wrapped wire component.

A further object of the present invention is to provide a protective garment, including but not limited to, gloves, aprons, arm shields, jackets and sporting equipment such as fencing uniforms, made from the composite yarn of the present invention.

These and other objects of the invention have been satisfied by the discovery of a composite yarn comprising:

a. a core comprising at least one fiberglass strand and at least one wire strand of diameter sufficient to provide cut resistance, wherein the at least one fiberglass strand and the at least

one wire strand are parallel to one another or twisted about one another and wherein only the core of the yarn contains metal; and

b. at least one non-metallic non-high performance fiber cover strand wrapped around the core in a first direction;

and its use in preparing a cut and abrasion resistant fabric, and articles and garments prepared from the fabric.

DETAILED DESCRIPTION OF THE INVENTION

The term "fiber" as used herein refers to a fundamental component used in the assembly of yarns and fabrics. Generally, a fiber is a component which has a length dimension which is much greater than its diameter or width. This term includes ribbon, strip, staple, and other forms of chopped, cut or discontinuous fiber and the like having a regular or irregular cross section. "Fiber" also includes a plurality of any one of the above or a combination of the above.

As used herein, the term "high performance fiber" means that class of synthetic or natural non-glass fibers having high values of tenacity greater than 10 g/denier, such that they lend themselves for applications where high abrasion and/or cut resistance is important. Typically, high performance fibers have a very high degree of molecular orientation and crystallinity in the final fiber structure.

The term "filament" as used herein refers to a fiber of indefinite or extreme length such as found naturally in silk. This term also refers to manufactured fibers produced by, among other things, extrusion processes. Individual filaments making up a fiber may have any one of a variety of cross sections to include round, serrated or crenular, bean-shaped or others.

The term "yarn" as used herein refers to a continuous strand of textile fibers, filaments or material in a form suitable for knitting, weaving, or otherwise intertwining to form a textile fabric. Yarn can occur in a variety of forms to include a spun yarn consisting of staple fibers usually bound together by twist; a multi filament yarn consisting of many continuous

filaments or strands; or a mono filament yarn which consist of a single strand.

The term "air interlacing" as used herein refers to subjecting multiple strands of yarn to an air jet to combine the strands and thus form a single, intermittently commingled strand. This treatment is sometimes referred to as "air tacking." This term is not used to refer to the process of "intermingling" or "entangling" which is understood in the art to refer to a method of air compacting a multifilament yarn to facilitate its further processing, particularly in weaving processes. A yarn strand that has been intermingled typically is not combined with another yarn. Rather, the individual multifilament strands are entangled with each other within the confines of the single strand. This air compacting is used as a substitute for yarn sizing and as a means to provide improved pick resistance. This term also does not refer to well known air texturizing performed to increase the bulk of single yarn or multiple yarn strands. Methods of air interlacing in composite yarns and suitable apparatus therefore are described in U.S. Patents 6,349,531; 6,341,483; and 6,212,914, the relevant portions of which are hereby incorporated by reference.

The present invention is directed to the concept of a cut-resistant composite yarn having cut-resistant properties comparable to yarns with high performance fiber, yet which have no expensive high performance fibers therein, and which contains no wrapped wire layers. In general yarns are formed of a core containing at least one strand of fiberglass, and at least one strand of wire, with one or more covers of conventional non-high performance yarn. Any one, two, or all of the core, and cover may include two strands. FIGS. 1-3 are exemplary of the various embodiments. Previously it was believed necessary to use a wrapped layer of wire, in order to avoid injury to the wire from stretching or from the impingement of an edge (such as a blade) against the wire. This injury to the wire typically manifests itself in the formation of bends or crimps, from the stretching and subsequent relaxing of the wire.

The present inventor has found, however, that it is possible to provide a yarn construction using adjacent fiberglass and wire strands in the core, without the need to wrap a strand of wire around the core, while avoiding the above noted injury to the wire. Within the context of the present invention, the term “adjacent strands” indicates that the strands are side-by-side, including both parallel arrangement and being twisted about each other. However, in the present invention, the construction contains no wrapped wire layer. While

not wishing to be held to any particular theory of operation, it is believed that the presence of the parallel strand of fiberglass provides a cushioning effect for the yarn, particularly the wire, which avoids production of the above mentioned bend or crimp. Further, since the fiberglass itself does not stretch, it is believed to serve as an "anchor" for the core of the yarn, thus avoiding high stretching forces from acting on the wire.

Turning to FIG. 1, there is illustrated one embodiment of a composite cut resistant yarn 10 which includes a core 12 formed of a single fiberglass strand 16 and a single strand of wire 18 (these strands are not shown to scale and can be a variety of sizes as noted below). This embodiment of the present invention cut resistant yarn 10 further includes a cover 14 having two cover layers formed from non-metallic, non-high performance fiber, 22 and 24. The first cover 22 is wrapped around the core 12, with the second cover 24 being wrapped around, preferably in the opposite wrapping direction from, the first cover 22.

In a second embodiment, illustrated in FIG. 2, the composite cut resistant yarn 10 includes a core 12 formed of a single fiberglass strand 16 and a single strand of wire 18 (again not to scale). This embodiment further includes a single cover 22 formed from a non-metallic, non-high performance fiber.

In an alternative embodiment, the core may include one or more additional strands. These one or more additional strands may be made of any non-high performance material, including but not limited to, fiberglass, wire, and conventional non-high performance fibers. These additional one or more strands may be arranged in the core either parallel or co-twisted with either or both of the fiberglass and wire core strands. Alternatively, if two or more additional core strands are present and are made from materials that are suitable for air-interlacing, these additional core strands may be air interlaced. One embodiment containing an additional parallel strand in the core is shown in FIG. 3, which illustrates a core 12, formed from a strand of fiberglass 16, a strand of wire 18 and an additional core strand of non-high performance fiber 19, with the cover 14 containing two cover layers 22 and 24 as described above.

In a further embodiment, the core contains a single strand of fiberglass parallel to a single strand of wire, wherein the single strand of wire is wrapped with a sheath strand of a

non-high performance fiber. This core is then wrapped with one or more cover layers of non-high performance fiber to provide the composite yarn.

In yet another embodiment, the composite yarn of the present invention can contain more than two cover layers, so long as no high performance fiber is used. This embodiment is illustrated in FIG. 4, which shows a core 12 formed of a single fiberglass strand 16 and a single strand of wire 18 (not to scale). The cover 14 contains three cover layers, 22, 24 and 26, each formed of a non-high performance fiber, and each successive cover layer being preferably wrapped in a direction opposite from the immediately underlying layer.

The wire used in the practice of the present invention desirably has a diameter of from about 0.0013 and about 0.0036 inch, preferably from about 0.0016 to about 0.0020 inch. Where two wires are used, they should preferably be of a diameter at the lower end of the range, e.g. about 0.0013 to about 0.0020. The wire strands of the present invention can be made from any metal conventionally used in yarns, and preferably are formed from an annealed stainless steel with the particular diameter of wire selected from the ranges specified above based on the desired properties and end use of the composite yarn.

The first cover strand and, if used, the second cover strand are comprised of a non-metallic, non-high performance fiber. The strands may be provided in either spun or filament form within a denier range of about 50 to about 1200. Suitable materials for the cover strands include, but are not limited to, polyester, polyester/cotton blends, acrylic, various types of nylon, wool and cotton. The choice of a particular material for the cover strand or strands will vary depending on the end use of the composite yarn and the physical characteristics (appearance, feel, etc.) desired for the yarn. The non-metallic, non-high performance fiber cover strands are wrapped about the core, or core covered with one or more cover layers, at a rate sufficient to enable processing of the composite yarn in conventional knitting and weaving equipment. Each successive cover strand is wrapped in a direction that is either the same as or opposite to the immediately preceding cover strand, preferably in the direction opposite that of the immediately preceding cover strand. While it is not necessary for the cover to be wrapped such that the underlying portion of the composite is completely covered, it is preferable to do so. More preferably, the cover strands are each, independently, wrapped at a rate of from about 6 to about 13 turns per inch.

The fiberglass strand (or strands) in the core may be either E-glass or S-glass of either continuous multi-filament, monofilament or spun, and can be of any desired size or denier. The practice of the present invention contemplates using several different sizes of commonly available fiberglass strand, as illustrated in Table 1 below:

TABLE 1

Fiberglass Size	Approximate Denier	Nominal Denier
G-450	99.21	100
D-225	198.0	200
G-150	297.6	300
G-75	595.27	600
G-50	892.90	900
G-37	1206.62	1200

The size designations in the Table are well known in the art to specify fiberglass strands.

These fiberglass strands may be used singly or in combination depending on the particular application for the finished article. By way of non-limiting example, if a total denier of about 200 is desired for the fiberglass component of the core, either a single D-225 or two substantially parallel G-450 strands may be used. In a preferred embodiment either a single strand or a combination of strands will have a denier of about between 200 and about 1200.

It should be understood that the table above illustrates currently available fiberglass strand sizes. The practice of the present invention contemplates the use of other fiberglass strand sizes as they become available in the market or as found to be suitable for particular applications.

Suitable preferred types of fiberglass fiber are manufactured by Coming and by PPG. The fibers have the desirable properties of relatively high tenacity, of about 12 to about 20

grams per denier, resistance to most acids and alkalis, being unaffected by bleaches and solvents, resistance to environmental conditions such as mildew and sunlight, and high resistance to abrasion and to aging.

Preferably the overall denier of the yarn of the present invention to include the fiberglass strand(s), the wire strand(s), and the covers is between about 300 denier and about 5000 denier. Further the combined mill weight of the fiberglass and wire components should be between 25% and 60% of the composite yarn.

The composite yarn of the present invention can be used as is, or can be subjected to various treatments to provide antistatic, antimicrobial, selective radiation absorbing (UV, IR, etc), dyeing or other desired properties. Preferably, such treatment(s) include imparting antimicrobial properties using a commercially available antimicrobial agent, such as those described, for example, in U.S. Patents 6,260,344; 6,266,951; and 6,351,932. These treatments can be used individually or in combinations of two or more. Such treatments are well known in the art and can be applied to the finished yarn, any portion of the yarn or the individual components of the yarn or portions thereof prior to assembly of the finished yarn, using conventional yarn treatment equipment.

EXAMPLES

By way of non-limiting example, yarn constructions demonstrating various embodiments of the present invention are illustrated as Examples 1-5 in Table 2 below. Examples 6-9 are included for comparative tests and will be explained hereinafter. The nomenclature "_X" refers to the number of strands of a particular composite yarn component used. In each instance, the 1st and 2nd cover layers are wrapped in opposing first and second directions (in case of a 3rd cover layer, it is wrapped in the same direction as the first layer, and opposite to the 2nd layer).

TABLE 2

Ex.	Core: Glass	Core: Wire Diam (in)	1st Cover	2nd Cover	3rd Cover	Composite Denier
1	G-450	2X0.0016 parallel	Polyester 150 Denier 9.4 tpi	Polyester 150 Denier 8.2 tpi		623
2	G-450	0.0016 parallel	Polyester 150 Denier 11.1 tpi	Polyester 150 Denier 8.8 tpi		546
3	G-37	0.0016 parallel	Polyester 500 Denier 8.3 tpi	Polyester 500 Denier 11.6 tpi	Polyester 1000 Denier 7.4 tpi	3635
4	G-225	2X0.0016 parallel	Polyester 150 denier 9.4 tpi	Polyester 150 denier 8.4 tpi		715
5	G-450	0.0016 parallel wire only wrapped with Z twist,150 denier textured polyester at 6.6 tpi	Polyester 150 Denier textured no twist 7.2 tpi	Polyester 150 Denier textured no twist 7.3 tpi		712
6	none	0.0016 wire parallel with 220 denier polyester	Polyester 150 Denier textured 7.0 tpi	Polyester 150 Denier textured 6.8 tpi		685
7	G-450	none	Wire 0.0016 in	Polyester 150 Denier 5.1 tpi	Polyester 150 Denier 4.1 tpi	531
8	G-50	0.0020 wire wrapped around glass at 9.1 tpi	Polyester 500 Denier 8.5 tpi	Polyester 500 Denier 9.9 tpi	Polyester 1000 Denier 7.5 tpi	3381
9	G-37	none glass parallel with 500 Denier Polyester	Polyester 1000 Denier 7.1 tpi	Polyester 1000 Denier 6.9 tpi		3995
10	G-150	none	Spectra® 200 Denier	Polyester 70 Denier	Polyester 70 Denier	

11	G-75	none	Spectra® 650 Denier	Spectra® 650 Denier	Polyester 1000 Denier
12	G-37	none	Spectra® 650 Denier	Spectra® 650 Denier	Polyester 1000 Denier

The Examples using a smaller denier core and cover would be knit using a 10 gauge or similar knitting machine. The Examples using larger denier core and cover would be knit using a 7 gauge or similarly sized knitting machine.

The yarn of the present invention may be manufactured on standard yarn-making equipment. If the yarn will be provided with three cover layers, preferably the fiberglass and wire core is wrapped with the first cover strand in a first step. Next, the second and, if used, third cover strands are added in a second operation on a separate machine. However, other procedures may be used as will be readily apparent to one of ordinary skill.

The yarn of the present invention has several advantages over the non-metallic cut resistant yarns described herein above. The fiberglass and wire core strands and the cover strand(s) mutually benefit each other. The fiberglass component acts as a support for the cut/abrasion resistant wire strand. Properties of the resulting yarn may be varied by varying the diameter and the rate of wrap (turns per inch) of the cover strand(s) about the fiberglass and wire core.

The cut resistance performance of the yarn of the present invention is shown in Table 3 below which compares the performance of the yarn constructed according to the present invention (without a high performance fiber) to a similar structure that includes a high performance fiber. Testing was conducted using ASTM test procedure F 1790-97. For this ASTM test the reference force is the mass required for the cutting edge of the test apparatus to travel one inch and initiate "cut through" in the material being tested. Cut resistance data collected using the ASTM test described above are summarized in Table 3 below. Each of examples 10-12 is a commercially available cut resistant composite yarn that includes a Spectra® fiber/fiberglass combination. The Spectra® fiber core strand is wrapped around the

fiberglass core strand in Examples 10 and 11. The Spectra®. fiber core strand is parallel to the fiberglass core strand in Example 12.

TABLE 3

Example	Cut Through Force (in grams)	Composite Denier (where known)
1	2164	623
2	2006	546
3	2788	3635
4	2560	715
5	1317	712
6*	1855	685
7*	2293	531
8*	3139	3381
9*	2928	3995
10*	2017	
11*	3251	
12*	3386	

* indicates comparative example

For comparable composite deniers, the yarn of the present invention provides a comparable cut resistance performance of a high performance fiber yarn at a significant cost savings because of the elimination of the high performance fiber, and comparable cut resistance compared to composite yarns having wrapped wire layers, without the need for wrapping wire. In some instances the present invention provides significantly improved cut resistance compared to the other constructions at similar composite denier.

Examples 10-12 show steadily improving cut-resistance performance results as the amount of high performance fiber and the size of the fiberglass core strand are increased. Surprisingly, the yarn of the present invention compares favorably with each of the examples that include a high performance fiber (given comparable composite denier and fiberglass size). The test results show that the comparatively low-cost wire/fiberglass combination provides a cut-resistance performance that is comparable to yarns containing a high performance fiber.

The composite yarn of the present invention can be used to prepare cut and abrasion resistant fabrics, which in turn can be used to prepare protective articles and garments. Turning to FIG. 5, a cut and abrasion resistant glove 40 according to the present invention is illustrated. The glove incorporates finger stalls 42 for each of the wearer's fingers. The cut-resistant yarn may be incorporated into a variety of other types of cut resistant garments and articles, including, but not limited to, arm shields, aprons or jackets, as well as sporting wear for sports such as fencing.

Although the present invention has been described with preferred embodiments and examples of those embodiments, it is to be understood that modifications and variations may be utilized without departing from the spirit and scope of this invention, as those skilled in the art would readily understand. Such modifications and variations are considered to be within the purview and scope of the appended claims and their equivalents.

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